EXHIBIT 4

Optimizing BMPs, Water Quality and Sustained Agriculture in the Lincoln Lake Watershed

Prepared for:

Arkansas Soil and Water Conservation Commission

By:

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Final Report

Executive Summary

The United States (US) has improved water quality in the last 25 years by protecting its waterbodies from industrial wastes and point sources. However, nonpoint source (NPS) pollution still remains a water quality concern. Sources of NPS pollution in the Ozark Highlands of Northwest Arkansas have been linked to agricultural activities in the area (Edwards and Daniel, 1992; Edwards et al., 1997). Rolling hills in this region are home to poultry farms and pastures that produce abundant forage for beef and dairy cattle. The predominant use of animal manures has been as fertilizer for perennial forage crops. There is ample evidence to suggest that excess land applications of animal manures have led to surface and ground water pollution due to increased runoff losses of nitrogen (N) and phosphorus (P), sediment, and pathogens (Edwards et al., 1996). Increasingly, watersheds are unable to utilize/degrade the high levels of nutrients from animal manure that are being applied.

Moores Creek watershed has been monitored continuously from 1991 to 2004, except for the period from October 1997 to December 1998. Monitoring of Moores Creek began after a project was initiated in the watershed to implement Best Management Practices (BMPs). Preliminary analyses from this 1991 project indicated a decrease in N transport (Edwards et al., 1996; Vendrell et al., 1997, 1999). However, none of the monitoring studies demonstrated a decline in P transport in the basin. There also had been no reports on the influence these BMPs have had on the abatement of NPS pollution exiting the watershed.

Very little historical biological data from the lake and groundwater data from the watershed were available that could be used to link the spatial distribution of BMPs and their effectiveness in water quality improvement. There was a need to perform an inventory of BMPs in conjunction with the stakeholder's input to characterize a reliable measure of the adoption and continued use of the BMPs by farmers. In addition, appropriate measures needed to be identified that would improve the water quality in the basin while sustaining the agricultural production and maximizing the landowner adoption of BMPs.

This project was funded by Arkansas Soil and Water Conservation Commission under 319(h) program (project number FY01-1100, Grant # 99610309). The project started August 2001 and end January 2005. The following cooperators were involved in completing different tasks in this project: Department of Biological and Agricultural Engineering, University of

Arkansas (BAEG, UA); Arkansas Water Resource Center (AWRC); University of Arkansas Cooperative Extension Service (UACES); and Washington County Conservation District (WCCD). The total funding for this project was $478,833. Federal funds were $272,713 and State/Local funds were $206,120.

The goal of this project was to develop an integrated watershed management plan by incorporating a process of public participation, issue identification, and consensus building; collecting chemical and biological data from Moores Creek and Lincoln Lake determining the improvement in water quality as a result of previously implemented BMPs and indicating problems that should be the focus of future BMP implementation; performing a GIS based integrated assessment of resource allocation, BMP effectiveness, and BMP needs that can sustain long-term agricultural production in the watershed while maintaining environmental quality; and organizing field trips/demonstration of stakeholders, farmers, and state agencies to educate them on the integrated watershed management process and linkages between farm-level production and water quality.

Specific tasks completed to achieve the project goals were as follows:

1. Water quality monitoring of Moores Creek and Lincoln Lake
2. Assessment of BMPs implemented in the watershed and their efficacies in improving water quality of Moores Creek
3. Preparation of watershed management plan and outreach/training/demonstration activities
4. Project management/Report writing.

Project Chronology

Description of the Watershed

Moores Creek (Figure 1) is a spring-fed second-order stream draining into Lincoln Lake. This catchment is a part of the smaller Lincoln Lake watershed and larger Illinois River Basin in the southwestern portion of the Ozark Plateaus in Washington County of northwestern Arkansas, USA. The headwater streams of the Illinois River basin have alluvial-gravel, riffle-pool geomorphology (Brussock et al., 1985). Streams substrate in this river basin are dominated by

limestone, sandstone, and shales and follow a karst topography. The dissolving of limestone causes formation of chert gravel deposits (Brown and Matthews, 1995) and alkalinity of the surface water.

The drainage area of Moores Creek is approximately 2120 ha (Vendrell et al., 1997). The major land uses in the watershed are pasture (62%), forest (26%), and urban (7%). Cotter (2002) reported that the watershed had 10 active poultry houses and 13 inactive poultry houses with an annual manure application rate 5600kg/ha in the watershed. Excessive land application of animal manure in the watershed had led to degradation of surface and ground water due to runoff losses of N and P, sediments, and pathogens (Edwards et al., 1996). Changes in water quality are important because Moores Creek drains to Lincoln Lake, a secondary drinking water supply for the City of Lincoln (Cotter, 2002).

Task 1. Water Quality Monitoring of Moores Creek and Lincoln Lake

The first task in the project consisted of water quality monitoring of Upper Moores Creek and Lincoln Lake. In completing this task, a Quality Assurance Project Plan (QAPP) was prepared and submitted to ASWCC. Monitoring was conducted by AWRC on Upper Moores Creek between August 2001 and July 2004.

A programmable datalogger was used in conjunction with a pressure transducer to measure and record water depth (stage). It converted the stage to discharge using a stage/discharge-rating curve developed in previous years. The datalogger initiated sampling by triggering the autosampler as soon as the stage had reached a depth of 26 inches. This trigger level was chosen initially in previous years to cause the upper sampler to begin taking samples at the same point in a storm hydrograph as the lower sampler. Once sampling had been initiated, the datalogger began calculating discharge and summing the total volume passing the sampler. Each time ten thousand cubic meters had passed, the sampler took a discrete sample, until it had taken 24 samples, or samples were retrieved. Once per day during storm events samples were retrieved from the sampler and it was reset to continue sampling until the stage had fallen below the trigger level. Each time samples were collected, equal volumes from each discrete sample were combined into one sample for analysis. These flow-weighted composite samples gave an accurate picture of the average concentrations for the entire storm event. In addition to sampling

This project could have also been enhanced by additional surface and biological monitoring (periphytometers) in Moores Creek and Lincoln Lake. This additional data would have provided us with greater understanding of the ecological system present in Moores Creek Watershed. However, the data collected in this project were adequate to meet the scope of this project.

Technical Transfer

This study on limiting nutrients, nutrient retention efficiency, and sediment nutrient interactions will help in enhancing the knowledge base of such issues for use by watershed managers. Information collected during field work and computer modeling provides watershed managers and stakeholders with appropriate information to seek further funding for continuing to improve the water quality in Moores Creek. The information gathered during this project was shared with landowners and stakeholders on two field days and eight meetings, organized with the cooperation of WCCD and UACES. Three newsletters and three fact sheet were also published during 2003 and 2004. In addition, project information, procedures and monitoring equipment was relayed through a two-day In-Service Training open to County Extension Agriculture Agents. The training was attended by all Agriculture Agents from the designated Nutrient Surplus Areas within the State.

This project encompassed water quality monitoring, peryphytometer deployment, nutrient retention experiments, sediment sampling, BMP assessments, watershed modeling, and economic modeling. Specific information that was presented using the various mediums (presentations, reports, news letters, fact sheets, field days) included:

1. Nutrient concentrations (NH_4-N, TKN, PO_4-P, and TP) have declined in Moores Creek from 2001 to 2004. This implies that BMPs may have had the desired effect in controlling the nutrient runoff from the watershed.
2. Incident light on periphytometer was found to be the limiting factor on chlorophyll-a content. Nutrients (N and P) were not limiting algal growth at all sites in Moores Creek during the study. This in conjunction with the data obtained from nutrient injections showed the importance of maintaining a good riparian area for effective water quality